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CONTROL OF GRAPE DISEASES AND INSECTS IN THE EASTERN UNITED STATES

FARMERS' BULLETIN NO. 1893
U.S. DEPARTMENT OF AGRICULTURE

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Washington, D.C. Revised July 1961

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Washington 25, D.C. - Price 20 cents

CONTROL OF GRAPE DISEASES AND INSECTS IN THE EASTERN UNITED STATES

By J. R. McGrew, *pathologist, Crops Research Division,* and G. W. Still and Howard Baker, *entomologists, Entomology Research Division, Agricultural Research Service*[1]

The damage done to grapes in the Eastern United States by diseases and insects varies considerably in different regions and from year to year. Weather conditions during the critical periods for infection may either favor or suppress the development and spread of the organisms causing the diseases. In some districts of the Northeastern States grape diseases are so easily controlled that in some years one or two applications of a fungicide are sufficient, whereas in other years the general spray schedule is hardly adequate. Grape diseases are more prevalent and more difficult to control in the Southeastern States because of prevailing high temperatures, abundant rainfall, and long growing season.

Grapes are subject to attack by a large number of insects. Only a few of the economically important insects are mentioned in this bulletin.

The general spray schedule (p. 30) is intended for average condi-

[1] The previous edition of this bulletin was prepared by J. B. Demaree and G. W. Still.

GENERAL PRECAUTIONS

Some fungicides may be injurious to man and animals. Observe carefully the manufacturer's recommendations on the container for safe handling.

Insecticides are depended on to prevent insect damage to grapes. They are poisonous to man and animals. Handle them with care. Store them in clearly labeled, closed containers in a dry place out of reach of children, pets, and farm animals. Follow directions for their use and observe all precautions on container labels. Change and launder clothing and bathe daily when applying insecticides. Avoid repeated or prolonged contact of insecticides with skin and inhalation of dusts and mists. Wash hands and face thoroughly after applying any insecticide, especially before eating or smoking.

Burn or bury empty insecticide containers.

To protect fish and wildlife, do not contaminate streams, lakes, or ponds with insecticides.

If overexposure to insecticides results in ill effects, consult a physician immediately. If an insecticide is swallowed, induce vomiting immediately. Then have the victim lie down and keep quiet. If a concentrate or oil solution is spilled on the clothing or skin, remove contaminated clothing and wash the skin with soap and water. If your physician needs information concerning symptoms and treatment of actual or suspected poisoning by insecticides, have him call the U.S. Public Health Service at its nearest office or at Atlanta, Ga., Phoenix, Ariz., or Wenatchee, Wash.

tions and will usually prove adequate in controlling the diseases and insects most commonly encountered.

The varieties of grapes grown affect the amount of disease. The vinifera, or European, varieties are very susceptible and cannot be grown successfully east of the Rocky Mountains, except in a few favorable districts. Varieties of the American bunch grape differ greatly as to susceptibility to disease. The muscadine grapes are highly resistant to the more destructive diseases.

DISEASES PRINCIPALLY OF AMERICAN BUNCH GRAPES

BLACK ROT

Black rot is caused by a fungus.[2] It is the most widespread disease of grapes, and in the eastern grape-producing districts it causes greater loss than all other diseases combined. It is rather generally distributed in most of these districts east of the Rocky Mountains, but it is most prevalent and destructive east of the Mississippi River. It is especially destructive in the hotter, humid part of this region and west along the gulf coast of Louisiana and Texas.

All vinifera, or European, varieties of grapes and many of the American bunch grapes are highly susceptible to black rot fungus. The following varieties of American bunch grapes are somewhat resistant to black rot and are of fair to good quality: Beta, Campbell Early, Clinton, Delaware, Elvira, Lutie, Missouri Riesling, Moore Early, Norton, Portland, Sheridan, and Worden.

The fungus causing black rot may attack the leaves, young canes, tendrils, and fruit. Only the youngest tissues are susceptible, although the fruit may become infected until it is almost fully grown. Rotting of fruit after it begins to color is generally caused by other fungi.

About 2 weeks elapse between the actual time of infection and the appearance of typical spot symptoms. Although spotting occurs on the leaves (fig.1) and vines early in the spring, the disease does not attract much attention until midsummer, when the nearly half-grown berries begin to rot. The disease on the fruit first appears as light-brownish, soft, circular spots, which enlarge rapidly, and within 2 or 3 days the entire berry is discolored. Within the next day small black specks begin to appear on the discolored berry. Very soon the decaying berries begin to shrivel, and within a week or 10 days they are transformed into black, hard, shriveled mummies, which may remain attached to the bunch for several weeks (fig. 2). Some shattering of the berries may occur, depending on the variety, during the period of rapid decay and before they shrivel. After they become mummified, they are not readily dislodged. The attached dried fruit is covered with very small pimplelike structures, which produce infective spores.

The fungus remains dormant through the winter, but during the warm, moist weather in the spring new spores are produced and they infect the young leaves and shoots. Thus the rot organism is perpetuated from one season to the next. The abundance of the disease from season to season depends on the weather conditions during the spring and the early summer and on the amount of diseased material carried over on the vines, fallen leaves, and fruit from the previous season.

If the vines are not sprayed early with the proper fungicide, the fungus may attack the young shoots

[2] The causal organisms of grape diseases are given on p. 32.

BN-11672

Figure 1.—American bunch grape leaf attacked by black rot fungus.

and foliage and build up a great reservoir of spores capable of infecting the fruit later in the season. In the South and where black rot has caused considerable loss, spray when the new shoots are 1 or 2 inches long. Then follow the general spray schedule (p. 30).

During unusually wet seasons an additional spray between sprays 4 and 5 (p. 30) may be necessary, especially if the disease is on the

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Figure 2.—Cluster of grapes showing black rot injury. Note mummified berries.

fruit at this time. Exact timing of the spray immediately after bloom is of utmost importance, especially when rainfall or dew occurs during or immediately after the bloom period.

Since black rot and some other grape diseases are more destructive in the Southern States, where summer rains are more frequent and the growing season is longer, a greater number of applications is required. For more detailed information on spray schedules, write to your State agricultural experiment station.

The choice of fungicides for black rot will depend on the degree of disease control desired, ease of preparation, and size of the planting. Bordeaux or copper-lime mixtures will control both black rot and downy mildew. However, they are slightly phytotoxic and will damage young leaves and stems. Ferbam will control black rot, but it is ineffective against downy mildew. Zineb is almost as effective as bordeaux mixture against both fungus diseases and is less phytotoxic. Because zineb is easier to prepare, it is generally recommended for small or home vineyards. In some areas captan at 2 pounds per 100 gallons of water may be recommended.

DOWNY MILDEW

Downy mildew is a fungus disease, primarily of grape foliage. It often becomes rather destructive to the leaves in unsprayed vineyards in the Ohio River Valley, the Great Lakes region, and the Northeastern States as far south as southern Virginia. Since the fungus is favored by cool, moist weather, the disease is of minor economic importance in the South.

The older leaves in the center of the vine are the first to become infected. The disease spreads toward the foliage at the end of the canes as the leaves mature, and by autumn on highly susceptible varieties even the newest leaves may succumb and complete defoliation result. On the other hand, if the season has been unfavorable for the spread and rapid growth of the fungus or if the grape variety is resistant, only a few of the oldest leaves may show the disease symptoms.

The fungus overwinters in the old diseased leaves on the ground. Weathering and decomposition liberate the spores during the spring. Splashing rain or wind causes some spores to reach the new leaves or the fruit, where infection starts. Only minor damage is done to the foliage before late summer. The greatest damage is during August and September.

The first evidence of infection on the leaves appears as light-yellow

68720

Figure 3.—Downy mildew on underside of grape leaf.

spots on the upper leaf surface. Later a white moldy growth of fungus threads and spores forms on the undersurface of the leaves (fig. 3). The spots may be few or numerous. When they merge, they may affect most of the leaf surface. Invasion of the fungus kills the leaf tissues, and then affected parts turn brown. Such leaves finally become dry and crumpled. When they fall, the clusters of fruit may be scalded by the sun. Vines losing their leaves before the ripening season cannot mature the fruit normally. Consequently, it is of inferior quality.

The disease may also attack the shoots, tendrils, and fruit early in the season when they are tender (fig. 4). These infections appear as water-soaked depressions, without any other diagnostic characters, unless a white moldy growth develops similar to that on the underside of the leaves.

The severe injury produced by the herbicide 2,4–D, to which grapes are extremely susceptible, may be confused with the injury caused by downy mildew. However, with 2,-4–D the white moldy growth of the fungus is not present.

During years when the fruit is attacked by downy mildew, there may be two waves of infection during the season. The first is in June, when the grape berries are about the size of small peas. When the berries are infected at this period, they become soft, shatter easily, and are frequently covered with the white downy growth of the causative fungus (fig. 5). During the hot part of the summer there is less evidence of mildew rot, but when nights become cooler, the second wave of infection may occur. As a rule, the fruit infected at this time does not soften and have the downy growth; instead it becomes brownish, withers, and shatters easily.

Downy mildew of grapes is comparatively easy to control. It seldom causes damage in vineyards that are sprayed regularly for protection against black rot, provided bordeaux mixture is used. However, ferbam, which is so effective against black rot, will not control downy mildew. Captan at 2 pounds per 100 gallons of water or zineb may be used to control downy mildew in later applications. See the general spray schedule (p. 30).

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Figure 4.—Tips of grapevine killed by downy mildew.

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ANTHRACNOSE OR BIRD'S-EYE ROT

Anthracnose is caused by a fungus. It occurs in some sections of the Northeastern and Southeastern States, but it is usually localized and confined to a few varieties. It may do considerable damage in a vineyard or a locality for a few years and then disappear.

The effect of the disease on the fruit and other parts of the vine is rather striking. This disease is not easily confused with other grape diseases. The fruit, young shoots, tendrils, petioles, leaf veins, and fruit stems may be attacked severely.

Numerous spots sometimes occur on the young shoots. Some spots

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Figure 5.—Downy mildew on young grape berries. (Courtesy Department of Plant Pathology, Cornell University.)

Anthracnose has seldom been reported on Concord, the most widely grown variety in the Eastern States. Other highly resistant eastern varieties are Beacon, Delaware, Herbemont, Lutie, Moore Early, Niagara, and President. The most susceptible varieties are Campbell Early, Catawba, Champion, Diamond, Diogenes, Ellen Scott, Norton, and Salem.

will unite and cause girdling, which results in death of the vine tips. Similar spots develop on the petioles and leaves, especially on the undersurface of leaves. Badly infected leaves curl downward from the margins, becoming distorted and spotted, and the diseased areas drop out so that the leaf appears ragged.

On the fruit the spots are circular, sunken, and ashy gray. In the late

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Figure 6.—Anthracnose on fruit and vine of grape. (Photographed from painting by J. M. Shull.)

stages of the disease the spots are surrounded by a dark margin. The name "bird's-eye rot," sometimes applied to this disease, is derived from the appearance of the spots on the berries (fig. 6).

To obtain good control of anthracnose, use a spray containing one part of concentrated lime-sulfur to nine parts of water during the dormant season, followed by four or five applications of bordeaux mixture or ferbam as for black rot (p. 30). Remove and burn all affected parts of the plant as they appear.

RIPE ROT AND BITTER ROT

Other rots that appear on the fruits when they begin to mature are ripe rot and bitter rot, which are caused by fungi. There are no clear-cut diagnostic features to distinguish these diseases, except that the causal fungus of bitter rot imparts a bitter taste to decayed berry pulp.

These diseases are not troublesome in well-sprayed vineyards, provided the general spray schedule for black rot is followed (p. 30). Since these diseases do not appear until the grapes begin to mature, the later sprays for controlling black rot and downy mildew are necessary to protect the berries during the ripening season.

DEAD ARM

Dead arm is primarily a disease of the trunk and main branches of the vine and is caused by a fungus. This disease has been reported from several Northeastern States. An epidemic has rarely been recorded, and the total loss each year is nominal. Nevertheless, the disease has been found in many vineyards.

The fungus that attacks the young shoots, the trunk, or the branches frequently enters the wounds or the parts affected by winter injury. After entering the woody tissues, it lives there year after year as a perennial parasite. The infected tissues are killed. A canker forms and enlarges each year until it finally girdles the branch or trunk, causing the death of the part of the vine above the canker. Often a new shoot develops near the canker. Generally it will be weak and its foliage dwarfed and curled, and usually it will die the following winter.

To control dead arm, remove the diseased parts of the vines well below the margins of the canker and burn them as soon as they are found. A delayed dormant spray of bordeaux mixture (8:8:100) or captan at 2 pounds per 100 gallons of water early in the spring when new buds are beginning to open will protect against the causal fungus of dead arm.

POWDERY MILDEW

Powdery mildew is caused by a fungus. It is present in many vineyards, but it is of little economic im-

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Figure 7.—Powdery mildew on upper side of grape leaf.

portance in the Eastern States. However, it is considered the most damaging fungus disease of vinifera grapes in California.

East of the Mississippi River powdery mildew is largely a disease of the foliage and cluster stems. It appears as a white, powdery, superficial growth on the upper side of grape leaves and other green parts of the vine (fig. 7). Severely affected leaves turn brown and fall. If the berries are infected, the surface appears russet or scurfy. They fail to mature properly, but no rot is associated with this injury. Infection of the cluster stem may cause shelling if the harvested fruit is not used immediately.

Powdery mildew is usually absent in vineyards sprayed to combat black rot and downy mildew. See the general spray schedule (p. 30). If powdery mildew should become severe, spray with 5 to 10 pounds of sulfur per acre.

ROOT DISEASES

The roots of grapes are attacked by several organisms, which cause either swellings or decay. Root diseases are not easily diagnosed. It is often necessary to remove a plant or a part of the root system from the soil in order to examine it for suspected root diseases. In general, the symptoms of root diseases are slow growth of the vine, low productivity, small, scant, yellowish leaves, and wilting. Do not plant grapes in soils infested with crown

gall or cotton root rot organisms. Little or nothing can be done to eliminate these organisms after they have become established in a vineyard.

Crown Gall

Crown gall, although not a serious grape disease in the Eastern States, is conspicuous on the vines when it occurs. It is caused by a bacterium, which is ordinarily considered to be a wound parasite of the roots and trunk. When the roots are affected, large more or less spherical galls develop, usually near the ground line. Sometimes they become as large as walnuts (fig. 8). The crown gall organism is widely distributed and attacks various fruit trees and shrubs.

Because the causal organism lives in the soil, it cannot be controlled by spraying. Where galls are confined to the branches or trunk, remove all affected tissue below the gall. Examine new plants before planting, and discard any that have galls.

Cotton Root Rot

The cotton, or Texas, root rot disease occurs chiefly in Texas, Oklahoma, and the States westward. It is caused by a soil-infesting fungus that attacks the roots of many plants besides grape. High soil temperature, abundant moisture, and highly alkaline soils are favorable for the growth and spread of the fungus.

A dull-yellowish foliage and a tendency of the plants to wilt during midafternoon are early symptoms. Badly affected plants may die suddenly. The disease spreads from plant to plant, involving ever-widening circles around the first plant to die. The root system of affected plants shows extensive killing and decay of tissue. A network of buff-colored fungus strands is abundant on the surface of diseased or dead roots. During the summer

BN-11671

Figure 8.—Crown gall on grape root at surface of soil.

when frequent rains occur the fungus produces conspicuous spore mats on the surface of the soil under or near affected vines. At first these spore mats resemble cotton, but later they become buff colored and powdery.

Since the disease is difficult to combat if the causal fungus becomes established in a vineyard, treat promptly to prevent rapid spread. Apply ammonium sulfate or ammonium phosphate at 10 pounds per 100 square feet of soil surface somewhat beyond the area of infected vines and just before a rain if possible or follow with a 3-inch irrigation if available.

PIERCE'S DISEASE

This virus disease is transmitted by several species of sharpshooters, or large leafhoppers. It has long been recognized in California and is apparently widespread throughout the Southeastern States. Much of the degeneration in American bunch grape plantings in these States has been attributed to Pierce's disease.

Muscadine grapes are tolerant of the virus as is the variety Lake Emerald, which was released by the

Florida Agricultural Experiment Station. Older varieties that are apparently tolerant of Pierce's disease include Champanel, Herbemont, and Lenoir.

Symptoms of this disease differ widely, depending on the season and the variety. They include (1) delayed foliation; (2) dwarfing of shoots; (3) scalding and dying of leaf tissue, which give a concentric pattern, with dead tissue at the margins, a line of yellow, and normal green at the center of the leaf; (4) wilting or premature coloring of fruit; (5) uneven maturation of canes in the fall resulting in islands of green or brown tissue on growth of the current year; and (6) gradual dying of root system and degeneration of vine.

Pierce's disease causes obvious damage only in the Gulf States. Once a vine is infected, there is no cure. However, damage from this disease can be prevented or reduced by using only varieties that are tolerant of the disease and adapted to the area.

OTHER VIRUS DISEASES

Several other virus diseases of grapes have been recognized. They may affect only certain varieties, especially those with considerable vinifera parentage, and may not produce obvious symptoms. Among the symptoms are premature scorching of leaves in the fall, delayed maturity of fruit, reduced sugar content of fruit, and general reduction in vigor and productivity of vines.

Once a vine is infected with a virus, there is no cure. Propagations from such a vine will carry the virus. Thus, only the most productive vines should be selected for propagation.

DISEASES OF MUSCADINE GRAPES

BLACK ROT

The fruit of such muscadine grape varieties as Hunt, James, Mish, Scuppernong, and Thomas is relatively free of diseases. Black rot, the most damaging disease of the fruit of the American bunch grape, does a negligible amount of damage to the muscadine fruit. Infection by black rot as a rule does not cause decay on muscadines but results in a black, shallow, scablike defect (fig. 9).

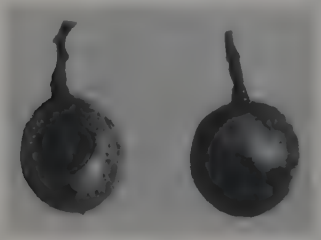

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Figure 9.—Effect of black rot on muscadine grapes.

However, the blossoms are susceptible to black rot fungus. A few days of cloudy, rainy weather during the blossoming period will favor infection and sometimes result in a heavy drop of blossoms. The black rot fungus causes considerable spotting on the foliage of muscadine grapes. In seasons favorable for the fungus, the spots are rather conspicuous and numerous, and a large part of the leaf area may be destroyed (fig. 10). The foliage of Mish and Scuppernong is very susceptible to this disease.

Spraying to control black rot on muscadine grapes is not considered generally to be profitable, except during an unusually wet season.

BITTER ROT

Bitter rot (see p. 7) is the major cause of muscadine fruit loss be-

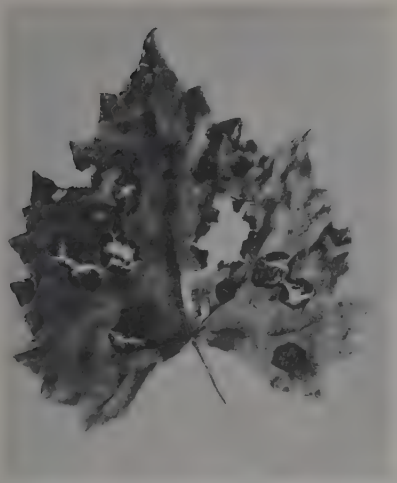

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Figure 10.—Spots caused by black rot fungus on leaf of muscadine grape.

tween the time of fruit set and harvest. It decays and shatters the fruit. Some varieties of muscadines may shatter whether this fungus disease is present or not. On certain varieties, such as Topsail, the fungus may spot or fleck the foliage, as well as affect the fruit.

In vineyards where this disease has been severe, it may be economically practical to apply bordeaux mixture (4:4:100) a month before harvest plus a later spray of captan at 2 pounds or zineb at 1½ pounds per 100 gallons of water. Zineb should not be used later than 7 days before harvest.

CERCOSPORA, OR ANGULAR, LEAF SPOT

Cercospora, or angular, leaf spot is caused by a fungus. It is the most economically important disease affecting the foliage of muscadine grapes. All commonly grown varieties are susceptible, although Flowers, Scuppernong, and Thomas are more resistant than Creek, Howard, Hunt, and Stuckey. The causative fungus does not attack the berries.

The first disease symptom is angular, or irregular, brown spots surrounded by a light-yellowish halo on the upper surface of the leaf. The spots enlarge and some combine, affecting a considerable area of many leaves. Under humid conditions great numbers of spores form on both leaf surfaces, but they are more abundant on the lower side. They are a light-olive color. The spores are washed away by rains when the spots, especially on the undersurface of the leaf, are black and appear pimply when magnified (fig. 11). Severe infection on the more susceptible varieties results in defoliation and impaired quality of the berries.

The disease may be easily controlled by applying bordeaux mixture (4:4:100) at 2- to 3-week intervals during the first half of the growing season. However, this treatment is necessary only when the disease has become established in a vineyard. Since the fungus

Figure 11.—Muscadine grape leaf spotted by Cercospora.

spores that start the early-spring infections overwinter on the old fallen leaves, removal or plowing under the old diseased leaves prior to the growth of the new spring foliage is generally sufficient.

INSECTS AND OTHER PESTS

GRAPE BERRY MOTH

Grapes are frequently injured by the larva of the grape berry moth,[3] an active, greenish caterpillar about three-eighths inch long when full grown. Larvae of the first brood of this pest feed in the blossoms or very young fruit clusters and in the newly formed berries. Those appearing later injure the green and ripening berries (fig. 12, *A*), often causing serious losses. One larva may injure several berries. On completing its feeding, the caterpillar leaves the berries and cuts out a small bit of leaf, folds it over, and constructs a cocoon within the fold (fig. 12, *B*). The leaf folds containing the cocoons may remain attached to the leaves or they may break off and fall to the ground. Caterpillars of the first brood usually construct their cocoons on the grape leaves on the vine during June or July. Those of the second brood usually drop to the ground and form their cocoons on small pieces of leaves under the grape trellis (fig. 12, *C*).

The insect overwinters in the cocoon (fig. 12, *D*). Late in the spring or early in the summer the inconspicuous brownish moths (fig. 12, *E*) emerge and lay their eggs on the grape stems or berries.

The grape berry moth is found throughout most of the Eastern States and is especially troublesome in the region north of the Ohio River, east of the Mississippi River, and on through New England.

To control the grape berry moth, a combination of methods is suggested. In vineyards in northern Ohio certain cultural practices aid in lowering the overwintering population to the point where sprays 3 and 4 or 3, 4, and 5 (p. 30) will give good control or the general spray schedule (p. 30) will give better control than it would otherwise. If herbicides are used in lieu of cultural practices to control weeds, the general spray schedule may be required.

In the preferred method of cultural control, throw a low ridge of soil under the trellis with a grape hoe, disk, or plow from 30 to 45 days before harvest. Make the ridge flat and wide and the row center almost level. The overwintering cocoons (fig. 12, *D*), which later accumulate on top of the ridge, will be exposed to natural destructive agencies during the winter. In the spring pull the ridge out into the row centers and disk the centers (fig. 13) to cover the cocoons. A shallow, compact covering about 1 inch thick will prevent moth emergence. If preferred, throw the soil toward the grape trellis in the spring to form a smooth, compact covering over the cocoons underneath. With either method complete the operation at least 15 days before the average date of grape bloom and leave the covering undisturbed until at least 15 days after grape bloom.

In addition to the cultural treatment, apply a DDT spray (1) immediately before or immediately after grape bloom, (2) 10 to 15 days after bloom, (3) 35 to 45 days after bloom, and (4) 10 to 15 days later. Apply the last DDT spray at least 40 days before grape harvest to avoid excessive spray residues on the fruit. Use a spray containing 1½ pounds of 50-percent DDT wettable powder per 100 gallons of water at 200 to 300 gallons per acre

[3] For the scientific names of insects mentioned in this bulletin, see p. 32.

BN-11745X, FrI-1402, BN-11759X, BN-11754X, BN-11747X

Figure 12.—*A*, Cluster of grapes injured by grape berry moth; *B*, cocoons of moths on fallen grape leaf (cocoons are hidden under small flap of cut and folded leaf material); *C*, overwintering cocoon of grape berry moth (indicated by arrow) on ground under trellis; *D*, cocoon and pupa within an opened cocoon (about four times natural size); *E*, adult (about 4½ times natural size).

depending on the density of the foliage. Fewer applications may be adequate in vineyards in which the grape berry moth is not a serious problem. A fungicide (p. 26) to control diseases may be combined with the grape berry moth spray. A commercial sticker (p. 29) may be used at the manufacturer's recommendations with sprays 3 and 4 (p. 30), but omit it in subsequent sprays to reduce the residue on the fruit at harvest.

Two pounds of 50-percent methoxychlor, 1 pound of 25-percent EPN, or 1 pound of 15-percent parathion wettable powder per 100 gallons of water may be substituted for the DDT in sprays 3 and 4 (p. 30). Control may be improved by using parathion in combination with DDT or methoxychlor at the above rates in sprays 3, 4, and 5. Parathion and methoxychlor can be used to within 14 days and EPN to within 21 days of harvest.

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BN-11755X

Figure 13.—Cultipacking grape rows after early spring cultivation of grapes to cover overwintering cocoons of grape berry moth with light, compact layer of soil to prevent moths from emerging.

Do not use parathion or EPN in small home plantings. They are dangerous and should be used only by a trained operator. See Caution, page 28.

GRAPE LEAFHOPPERS

Grape leafhoppers, *Erythroneura comes* (Say) and related forms (fig. 14, *A* and *B*), are often abundant during the summer on the lower surface of grape leaves. These small, agile, white or pale-yellow insects with red or yellow markings occur wherever grapes are grown. They feed by sucking juice from the leaves, causing them to become blotched with white (fig. 14, *C*) and later to turn brown. Many leaves fall from the vines prematurely. This injury prevents normal vine growth and interferes with the proper ripening of the fruit.

The insects overwinter as adults in protected places, usually in trash on the ground in, or close to, vineyards. With the first warm days of spring the leafhoppers become active and feed on any green vegetation they can find, but they concentrate on the new grape leaves. Eggs are laid in the leaf tissue. There are two or three generations of these insects each season.

To control the grape leafhopper, spray with DDT, methoxychlor, or malathion. One thorough application immediately after grape bloom is usually sufficient. Use a spray containing 1½ pounds of 50-percent DDT, 2 pounds of 50-percent methoxychlor, or 1½ to 2 pounds of 25-percent malathion wettable powder per 100 gallons of water. If overwintering leafhoppers are extremely abundant early in the spring before grape bloom and are seriously injuring the new shoots, it may be advisable to make a special application of DDT,

FrI-3427

Figure 14.—*A*, Adult grape leafhoppers; *B*, nearly full-grown nymph; *C*, mottled grape foliage injured by grape leafhoppers. Insects about 10 times natural size.

methoxychlor, or malathion at the above rates when the insects appear.

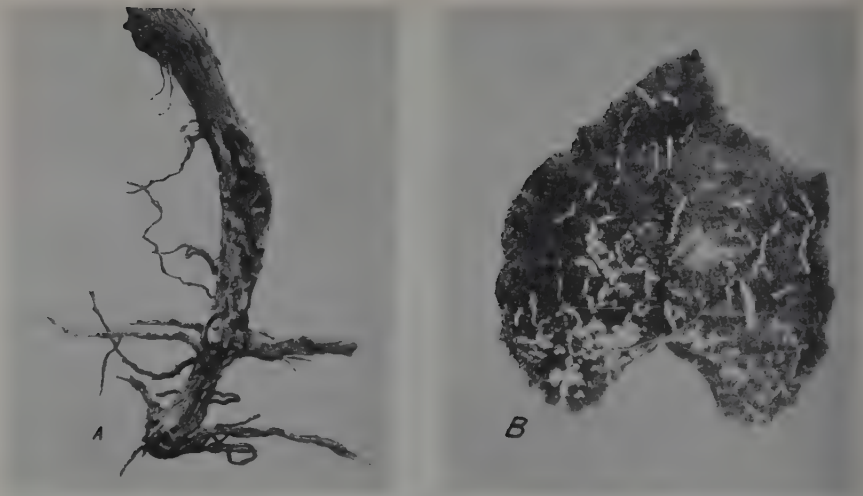
GRAPE ROOTWORM

The grape rootworm infests the roots of the grapevine (fig. 15, *A*), devouring more or less completely the small roots and rootlets and pitting and burrowing into the outer part of the larger roots. The adult—a small, hairy, chestnut-brown beetle—appears in vineyards of such varieties as Catawba, Concord, and Niagara shortly after the blooming period. It feeds on the upper surface of the leaves, eating to the lower surface through a series of patches or holes, which appear as characteristic chainlike feeding marks (fig. 15, *B*). However, the adult's injury to the foliage is unimportant compared to the larva's damage to the roots.

To control the grape rootworm adult, spray the foliage and vines with 1½ pounds of 50-percent DDT wettable powder per 100 gallons of water when the first feeding injury is noted on the grape leaves. The first and second sprays applied for grape berry moth control (p. 12) usually control the grape rootworm. If they do not, spray again about 10 days after the second spray.

ROSE CHAFER

In some localities in the Eastern States the rose chafer (fig. 16) causes severe injury early in the season to grape foliage, blossoms, and newly set berries. The beetles are general feeders and injure many kinds of fruits and ornamental plants. They sometimes fly into the vineyard in large numbers and consume most of the foliage, leaving only the larger veins. Their feeding period lasts from 3 to 4 weeks.



FrI-1905 and BN-11749X

Figure 15.—*A*, Injury by larvae of grape rootworm to roots of grapevine; *B*, feeding marks by adults on grape leaf.

This insect breeds largely in light sandy soils. In the larval stage it is a small white grub.

For effective control of the rose chafer, apply a spray containing 2 pounds of 50-percent DDT or methoxychlor wettable powder per 100 gallons of water. Spray as soon as the beetles appear, because they can do considerable damage in a 24-hour period. Sometimes it may be necessary to spray while the grapes are in bloom. More often a spray to control the rose chafer will be needed near the time of the first spray to control the grape berry moth. If so, a single application will suffice for both insects. A fungicide (p. 26) may be added to this spray for disease control.

BN-11752X

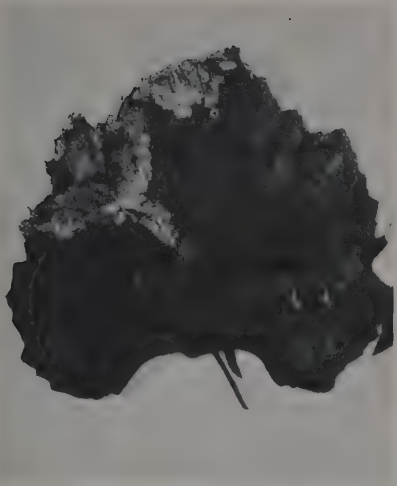
Figure 16.—Adult female rose chafer. About two times natural size.

LEAF-EATING CATERPILLARS

Many kinds of caterpillars feed on grape leaves. The grape leaf folder is an active, grass-green caterpillar nearly three-fourths inch long. It rolls or folds the leaves (fig. 17) and then feeds within the shelter thus formed.

The larva of the eight-spotted forester is a little more than an inch long. It has black and orange stripes across the body and a distinct hump near the hind end (fig. 18).

Several species of hornworms, which are large caterpillars from 2 to 3½ inches long, often injure grape leaves, sometimes completely defo-



Sandusky-2405A

Figure 17.—Injury to grape leaf by grape leaf folder.

liating the vines. One of them is the achemon sphinx (fig. 19).

The leaf-eating caterpillars are usually controlled with DDT in

FrI-2831

Figure 18.—Larva of eight-spotted forester. About 1⅓ times natural size.

sprays 2, 3, and 4 (p. 30). As DDT does not control all species of these caterpillars, add lead arsenate at 3 pounds per 100 gallons of water to sprays 1 or 2 (p. 30). To prevent excessive residue on the grapes, do not apply lead arsenate after the grapes appear.

In small plantings, handpicking the leaf-eating caterpillars may control most of them.

FrI-3420

Figure 19. Achemon sphinx, one of the hornworms injuring grape leaves. About natural size.

GRAPEVINE APHID

In vineyards east of the Mississippi River large numbers of the grapevine aphid are often found during the summer on the young shoots and leaves (fig. 20). This tiny dark-brown aphid is most likely to appear in dry weather and often disappears almost completely after a heavy rain. When the aphids are very abundant, they may infest the fruit clusters, causing some of the grapes to drop. In the fall the aphids leave the grapevines and migrate to the blackhaw, where they spend the winter and spring, returning to the grapevines early in the summer.

To control the grapevine aphid, spray the vines with a contact insecticide after the insects appear. Use 1 pint of nicotine sulfate (40-percent nicotine) per 100 gallons of water. Add either a small quantity of soap or combine the nicotine sulfate with bordeaux mixture in one of the sprays of the general spray schedule (p. 30). Parathion may also be used at 1 pound of 15-percent wettable powder or malathion at 1½ to 2 pounds of 25-percent wettable powder per 100 gallons of water.

Parathion is dangerous to handle. Do not use it in small home plantings. Follow all precautions on labels, in packages, and in this bulletin (p. 28).

FrI-2865

Figure 20.—Grapevine aphids on grape shoots and young leaves.

RED-BANDED LEAF ROLLER

Grapes may be damaged by the larva of the red-banded leaf roller throughout the Eastern States. It is a greenish caterpillar about three-quarters inch long when full grown. The caterpillar spins webbing in the grape clusters and feeds on the grape berries while protected by the web (fig. 21). The first brood of caterpillars may appear as early as April, and there are usually two or three broods each year.

Sprays applied just before or after grape bloom reduce damage caused by later broods without leaving excessive harmful residues on the berries. The red-banded leaf roller is not readily controlled with DDT. There-

BN-11757X

Figure 21.—Larva of red-banded leaf roller on grape stem. About two times natural size.

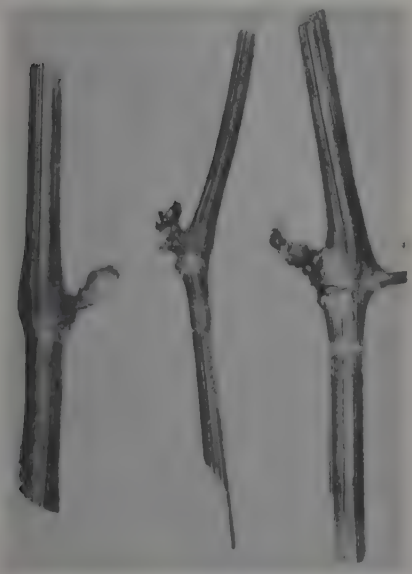
fore, when this insect is a problem, include 3 pounds of lead arsenate in sprays 1 and/or 2 or 2 pounds of 15-percent parathion wettable powder in sprays 2 or 3 per 100 gallons of water (p. 30).

Parathion is dangerous to handle. Do not use it in small home plantings. Follow all precautions on labels, in packages, and in this bulletin (p. 28).

CLIMBING CUTWORMS

Several species of climbing cutworms, including *Feltia* and *Agrotis* spp., occasionally attack and destroy grape buds in all commercially important grape-producing areas just as the buds begin to swell in the early spring. The worms eat the bud or eat holes in the bud (fig. 22) usually at night, when they come out from hiding under stones, rubbish, or weeds beneath the grape trellis and climb up the vines. Damage is usually confined to localized areas in a vineyard and seldom occurs after the grape shoots begin to develop.

The best way to protect grapes from cutworm injury is to place a small handful of 10-percent DDT dust on the lower part of the vine and on the ground below. Wear gloves while applying the dust. The cutworms contact the DDT as they climb on the vine and are killed by it. Other measures that will reduce cutworm damage include (1) a spray containing 2 pounds of 50-percent DDT wettable powder per 100 gallons of water just as the buds are swelling and (2) early cultivation under the vines in the infested part of the vineyard.

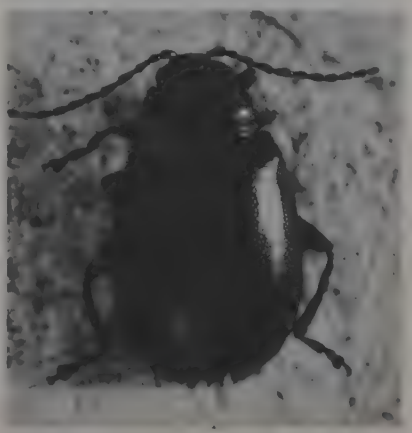


BN-11751X

Figure 22.—Grape buds (two on right) destroyed by climbing cutworms. Bud on left not damaged. About three-fourths natural size.

GRAPE FLEA BEETLE

The grape flea beetle adult is dark blue, shiny, and about three-sixteenths inch long (fig. 23). This insect overwinters as an adult in debris in or near vineyards in two-thirds of the Eastern States. Early in the spring, just as grape buds are swelling, it migrates to the grapevines and kills the buds by eating out the centers. As the secondary grape shoots develop, it lays eggs, and the worms, about one-fourth



BN-11743X

Figure 23.—Adult grape flea beetle. About 10 times natural size.

inch long when full grown, feed on the upper surface of the grape leaves. This insect usually occurs in local areas within a vineyard, especially near woods or buildings. The injury to the grape buds closely resembles that caused by climbing cutworms. Be sure to determine which insect is causing the damage.

Spray with 2 pounds of 50-percent DDT wettable powder per 100 gallons of water just as the buds are swelling or when the shoots are 6 to 8 inches long to control the adults or the immature worms.

GRAPE CURCULIO

The grape curculio adult (fig. 24) is a small, broad, dark-brown snout beetle about one-tenth inch long. It occurs from New England to Florida and west to the Mississippi Valley, but it is most likely to be present in injurious numbers from Ohio and West Virginia west to Illinois and Arkansas. The adult feeds on

FrI 5363

Figure 24.—Adult grape curculio resting on grape near partially completed egg chamber.

FrI-5369

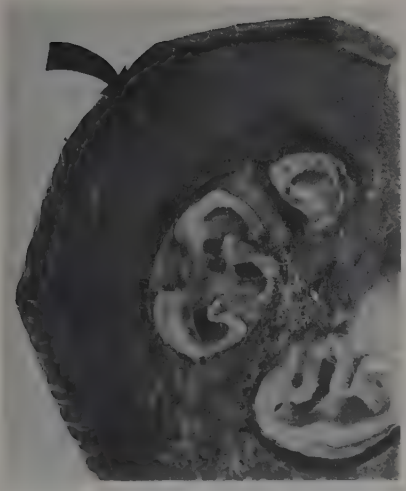
Figure 25.—Feeding marks on grape leaf made by grape curculio.

the foliage of wild and cultivated grapes and the larva feeds on the flesh and seeds of the berries.

The insect hibernates as an adult in or near vineyards, especially along the edge of woodlands. The adult becomes active in the spring, about the time the Concord is in bloom. It feeds on the upper surface of the foliage from 10 to 14 days before laying eggs. Feeding injury occurs as characteristic short, somewhat curved lines, usually in groups (fig. 25).

The eggs are placed singly in small shallow cavities, which the insect cuts into the berries during July and August (fig. 26). They hatch in about 6 days. The larva develops inside the berries, feeding on the flesh and seeds for about 3 weeks. When mature, it leaves the berries and constructs a small earthen cocoon, from which the adult beetle emerges in 3 or 4 weeks. After emergence, the adult feeds on grape foliage until it hibernates in trash in and near vineyards with the advent of cold weather.

To control this insect, use DDT or parathion as for the grape berry moth (p. 12).



FrI-5362

Figure 26.—Egg and egg chamber of grape curculio.

GRAPE MEALYBUG

The grape mealybug is a whitish insect that sucks juice from the canes, stems, and berries of the grapevine (fig. 27). There are two broods each year. The eggs are laid early in the fall in a cottony mass under the loose bark of the grape trunk. The eggs hatch in the fall, but the young mealybugs do not leave the cottony protection until early in the spring. They then crawl out from under the bark and up onto the developing grape buds and shoots. These insects mature early in the summer, and a second brood is started. It feeds mainly on the grape clusters.

Mealybugs secrete a sweetish honeydew fluid (fig. 28), in which a sooty mold develops. It gives the grapes an objectionable appearance and flavor. Injury by mealybugs also causes the cluster stems and grape berries to shrivel and fall.

BN-11758X

Figure 27. Grape mealybug (immature) feeding at junction of pedicle and grape berry. About seven times natural size.

BN-11744X

Figure 28.—Honeydew secretion on grape berries caused by feeding of grape mealybugs. About two times natural size.

Use a single spray application of 2 pounds of 15-percent parathion wettable powder per 100 gallons of water for adequate control of the grape mealybug. The spray may be applied 2 weeks before grape bloom or 6 to 8 weeks thereafter, but not later than 14 days before harvest. EPN at 1½ pounds of 25-percent wettable powder or malathion at 1½ pints of 57-percent emulsifiable concentrate per 100 gallons of water may also be used to within 21 and 3 days of harvest, respectively.

Parathion and EPN are dangerous to handle. Do not use them in small home plantings. Follow all precautions on labels, in packages, and in this bulletin (p. 28).

JAPANESE BEETLE

The Japanese beetle (fig. 29, *A*) is a shiny metallic green and less than one-half inch long, with coppery-brown wing covers. It appears on grapes early in the summer—about June 1 in parts of Virginia, June 15 near Philadelphia, and July 1 or later in New England. For 4 to 6 weeks the beetles feed heavily on grape foliage (fig. 29, *B*), particularly the part directly exposed to the sun, giving the foliage a lacelike appearance. Badly injured leaves soon drop. The eggs are laid in the soil, most commonly in grassy areas, where the grubs develop.

To protect vineyards from the Japanese beetle, spray the vines thoroughly with 2 pounds of 50-percent DDT wettable powder per 100 gallons of water when the beetles appear and at such intervals thereafter as new growth requires protection. Ordinarily the DDT sprays applied to control the grape berry moth will take care of the Japanese beetle at the same time. Do not apply DDT later than 40 days before grape harvest. Instead of DDT you may use 3 pounds of 50-percent methoxychlor, 2 pounds of 15-percent parathion, or 2 pounds of 25-percent malathion wettable powder or 1½ pints of 57-percent malathion emulsifiable concentrate per 100 gallons of water. Do not use methoxychlor and parathion later than 14 days and malathion later than 3 days before harvest. A spray containing 3 pounds of derris or cube (4 percent of rotenone) per 100 gallons of water will repel the beetles for a few days and can be used as late as the day before harvest. Dusting with hy-

BN-11748X and BN-11762

Figure 29.—Japanese beetle: *A*, Adult, enlarged; *B*, beetles feeding on grape leaf.

drated lime will also prevent some feeding.

Parathion is dangerous to handle. Do not use it in small home plantings. Follow all precautions on labels, in packages, and in this bulletin (p. 28).

GALL MAKERS

Swellings, or galls, of various kinds occur on grapes as a result of attack by several unrelated insects. Gall insects appear early in the season, sometimes 3 or 4 weeks before grape bloom. Most of them have several broods during the season. Fortunately infestations are limited to small areas in a vineyard, and injury to the vines or crop is not often serious.

Leaves covered with galls (fig. 30) may indicate an infestation by the grape phylloxera, a small aphidlike insect that attacks both roots and foliage. Root damage is especially serious on vinifera varieties of grapes, such as are commonly grown in California. Wild grapes in the East and varieties developed from them differ in their immunity to injury and thrive despite the presence of the insect. The leaf galls are common on some varieties of grapes in the East, but they are rarely found in the West.

FrI-3961

Figure 30.—Leaf galls of grape phylloxera.

The term "tomato gall" is used to describe masses of irregular succulent galls often found on wild and cultivated grapes (figs. 31 and 32). They are caused by *Lasioptera vitis* O.S., *Dasyneura vitis* Felt, and other species. The galls may be on the leaves, leafstalks, tendrils, or stalks of the fruit clusters and vary from greenish yellow to reddish. They are divided into tiny cells, in each of which an orange-yellow larva, or grub, develops. The adults are tiny flylike insects known as gnats, or midges. They appear in the spring in time to attack new, tender growth.

Pear-shaped, hazelnutlike galls (fig. 33), which are less than an inch in diameter, first greenish and then reddish as the season advances, are caused by the grape apple gall maker. These galls have exterior depressions extending lengthwise, which are divided into cells in which the bright-yellow larvae develop.

An enlargement on the cane, usually just above a lower joint, about twice the diameter of the cane, and 1 or 2 inches long, may result from a puncture by the grape cane gall maker, a small reddish-brown weevil. An egg is placed in this puncture, and several additional punctures may be made above the original one, but no additional eggs are deposited. The larva feeds in the pith, burrowing up and down the shoot. The beetle emerges in midsummer. The injured canes continue to grow and become enlarged at the puncture, but unless they are broken, little harm results.

Grape leaves sometimes have the upper surface more or less covered with slender galls, which are about one-third inch long and reddish to crimson, shading to green. These trumpet, or grape tube, galls are

BN-11761X

Figure 31.—Grapevine tomato galls on grape leaves.

FrI-4422

Figure 32.—Grapevine tomato galls on grape leaf and tendril.

caused by a small midge, or gnat, known as *Cecidomyia viticola* O.S. The larva, or grub, within the gall is pale orange.

Growers of vinifera grapes should plant vines only on phylloxera-resistant rootstocks. Growers of American varieties will seldom find the grape phylloxera of sufficient economic importance to require control measures. If necessary, foliage of American varieties can be protected from phylloxera damage. Spray with 2 pounds of 25-percent lindane wettable powder per 100

FrI 3294

Figure 33.—Grape apple galls.

gallons of water when galls first appear on the leaves and again 7 to 10 days later. Do not use lindane later than 1 month after bloom. If other gall insects are present, spray with 1½ pounds of 25-percent parathion or 2 pounds of 25-percent malathion wettable powder per 100 gallons of water when the galls first appear on the vines, usually before bloom, and then again later as other broods occur.

The use of these insecticides does not prevent formation of new galls a few days later on the new leaves and growth, but the size of the infestation and the number of new galls are reduced. This type of control would not be feasible in commercial vineyards, but it might be practical in home gardens.

Parathion is dangerous to handle. Do not use it in small home plantings. Follow all precautions on labels, in packages, and in this bulletin (p. 28).

BEES, WASPS, AND BIRDS

Bees attack the grape through injuries caused by other insects and by diseases, or through splits in the skins of overripe berries. Bees are not able to break the skins of sound grapes with their mouth parts. When the skin has been broken, they may quickly make the fruit worthless.

To avoid injury by bees, control other insects and diseases that injure the grape skin. Pick the grapes before they are overripe. In small home vineyards protect bunches of grapes with cheesecloth or paper bags, which are put on just before the grapes begin to ripen.

Wasps may also be attracted to overripe or injured grapes. Bagging protects the bunches from their attack.

During seasons when grapes mature and ripen early, small migrating birds may peck tiny holes in the grapes so that bees, wasps, pomace flies, and bacteria can enter and spoil the fruit for use or totally destroy it. Large birds, such as starlings, robins, crows, and sparrows, eat most of the grapes and leave practically nothing to spoil. These birds may generally be frightened from vineyards by exploding noise-making devices.

GENERAL RECOMMENDATIONS FOR GROWING SOUND FRUIT

DISEASE-RESISTANT VARIETIES FOR HOME GARDENS

The standard varieties of American bunch grapes grown in the Eastern States are important commercially, because they possess excellent table qualities, are suitable for making juice or wine, and are especially adapted to certain soils and climates. In addition, diseases and insect pests attacking them can be successfully controlled without much trouble and expense.

In the field, diseases cause very little concern to the growers where the vines are pruned regularly, sanitary measures are practiced, and spraying is properly done when needed. Often the same varieties grown in home gardens where the vines are crowded, shaded, and indifferently pruned will be diseased badly, even if sprayed frequently.

If you plan to grow a few grapes in a garden plot, select primarily disease-resistant varieties, with some sacrifice of fruit quality. A few varieties of fair to good quality can be grown, at least in the Northeastern States, with little or no spraying. Lutie would be worth trying. It is productive, the fruit is large and of fair quality, and it is resistant to black rot and downy mildew. In areas where downy mildew is not a problem, Campbell Early, Delaware, Lucile, and

Worden would be suitable, provided they are adapted to such areas.

BAGGING THE FRUIT

Those growing a few grapes for home consumption, as well as the growers producing more extensively for a discriminating market, can afford to cover the fruit clusters with ordinary paper bags immediately after the blossoms fall. Three- to five-pound paper bags are suitable. Tie the mouth of the bag securely around the stem of the cluster, or fold the bag over the vine above the cluster so that you can pin the corners or fasten them with paper clips. Bagging the fruit in this way should protect the clusters against insects and infection by rot fungi throughout the season.

SANITATION

Since the fungi causing grape diseases overwinter in an inactive state on or within old foliage, shattered fruit, or vines, dispose of this infected material prior to the unfolding of leaves and the development of spring shoots. Prune the grapevines annually and remove and burn all infected material.

Some cultural practices recommended for controlling the grape berry moth (p.12) should also help to control the diseases that are carried through the winter on old leaves or on shattered diseased fruit. Cover such leaves and fruit with a shallow layer of soil to prevent the wind and spattering rain from carrying the spores to new leaves and shoots. In small home-garden plantings burn the leaves and dropped fruit during the fall.

SPRAY MATERIALS

The spray materials mentioned in this bulletin can usually be obtained from local agricultural supply houses. Use materials from a reputable manufacturer.

Bordeaux Mixture

Bordeaux mixture is a fungicide that is best prepared at home and used within a few hours. The ingredients are copper sulfate, hydrated lime, and water. As copper sulfate may cause indigestion if taken internally, dispose of any unused mixture or cover it so that it will be inaccessible to children and animals. Bordeaux mixture also irritates the eyes and skin.

For spraying grapes, use from 2 to 8 pounds each of copper sulfate and lime per 100 gallons of water depending on the time of year and the diseases to be controlled. Use the type of copper sulfate that will dissolve immediately when added to the spray tank. To dissolve less soluble types of copper sulfate, suspend them in burlap bags in wooden vats containing water. The most convenient and available type of lime for the spray is hydrated lime, such as is used in the building trade. Use only fresh lime, as old lime is less effective, does not mix well, and tends to clog spray nozzles.

To prepare bordeaux mixture in a spray tank, fill the tank half full with water, start the agitator in the tank, and add the computed amount of lime based on the tank capacity. Allow the agitator to mix the lime thoroughly in the tank, then add the computed amount of copper sulfate. Fill the tank with water.

To prepare a small quantity of bordeaux mixture for spraying a home vineyard, use 2 level tablespoons of copper sulfate and 6 of hydrated lime to each gallon of water. This is equivalent to a 6:6:100 mixture. First add the lime to the water and stir until well mixed. Then add the copper sulfate and stir until dissolved. If the addition of an insecticide, or sticker, or both is desired, add them to the bordeaux mixture last. Mix the spray in the receptacle or tank. It will corrode galvanized metal.

Bordeaux mixture may be used at any time up to harvest. Since it leaves a visible residue on the fruit, other forms of copper are generally used for the last spray or two.

Other Spray Materials Containing Copper

Bordeaux mixture and several other spray materials with a higher metallic copper content than the standard copper sulfate may be obtained commercially. If these commercial materials are used to make a bordeaux or a copper-lime mixture for grape sprays, smaller quantities are required. Be sure to follow the manufacturer's directions. It is important that the amount of hydrated lime be equivalent to the amount, by weight, of copper spray material used. Several "fixed" coppers are available. Since the copper content varies, follow carefully the directions on the label.

Newer Organic Fungicides

Captan, ferbam, and zineb are compatible with all the insecticides mentioned in this bulletin. Do not mix these fungicides with bordeaux mixture or lime-sulfur.

Captan is a whitish powder, which is generally used at 2 pounds of 50-percent wettable powder per 100 gallons of water, or 2 tablespoons per gallon. It may be applied at any time up to harvest. Do not use more than 10 pounds per acre.

Ferbam, a black fluffy powder, is generally used at 2 pounds of 75-percent wettable powder per 100 gallons of water, or 2 tablespoons per gallon. Do not use more than 2½ pounds per acre, nor apply within 1 week of harvest.

Zineb is a tan powder, which is used at 1½ pounds of 65-percent wettable powder per 100 gallons of water, or 1½ tablespoons per gallon. Do not use more than 4½ pounds per acre, nor apply within 1 week of harvest.

Lead Arsenate

Lead arsenate is a powdery material that is used as a stomach poison for insects. In the pure form this chemical is white, but when sold for insecticides it is pink. It is a deadly poison. Store it where children and domestic animals cannot reach it. Protect your face and skin when handling this insecticide. Ordinarily use it at 3 pounds per 100 gallons of water for controlling leaf-eating caterpillars and the red-banded leaf roller. For smaller quantities, use approximately 4 rounded teaspoons of lead arsenate per gallon of water. Do not apply lead arsenate after grapes begin to form.

DDT

DDT sprays are used throughout the eastern grape-growing region to control a great many grape insects. In general, use a spray containing 1½ or 2 pounds of 50-percent DDT wettable powder per 100 gallons of water. For small amounts of spray, use about 1½ or 2 tablespoons of 50-percent DDT wettable powder per gallon of water. DDT mixes readily with water. It may be used in combination with fungicides, such as bordeaux mixture or ferbam, or with lead arsenate or parathion. Do not use DDT on grapes later than 40 days before harvest.

Caution: DDT is poisonous to human beings and animals. Avoid inhaling the dust or spray. Do not allow the spray to come into prolonged contact with the face or skin. Store DDT in well-marked, tight containers away from children and animals.

Methoxychlor

Methoxychlor is closely related to DDT and can be substituted for it in the control of the grape berry moth, the Japanese beetle, the rose chafer, and grape leafhoppers. In general, use 2 or 3 pounds of 50-percent methoxychlor wettable powder per 100 gallons of water. Methoxychlor is compatible with other insecticides and with fungicides recommended for use on grapes. It is markedly less toxic to warm-

blooded animals than DDT and one of the safest insecticides to handle. Do not use methoxychlor later than 14 days before harvest.

Lindane

Lindane is a formulation of the gamma isomer of benzene hexachloride. It is effective in controlling the grape phylloxera when it attacks leaves. For this purpose, use 2 pounds of 25-percent lindane wettable powder per 100 gallons of water. To avoid possible off-flavor in grapes, do not use lindane later than 1 month after bloom. Use all ordinary precautions in handling and storing this insecticide.

Parathion

Commercial parathion is a light-brown powder containing 15 or 25 percent of actual parathion. Use it to control the grape berry moth, the grape mealybug, the grapevine aphid, the Japanese beetle, the red-banded leaf roller, the grape curculio, and mites on grapes. The parathion wettable powders mix readily with water. Use a spray of 1 to 2 pounds of 15-percent parathion wettable powder per 100 gallons of water depending on the pest to be controlled. Parathion may be used in combination with ferbam, DDT, or lead arsenate, but lime, bordeaux mixture, and alkaline substances reduce its effectiveness. Do not use parathion later than 14 days before harvest.

Caution: Parathion is extremely toxic to human beings. It should not be used in small home plantings or by those not experienced in handling insecticides. Handle it with great care and only in the open air or in well-ventilated rooms. Avoid breathing the wettable powder while opening the bags or putting it into the spray tank. Avoid exposure to spray drift or dust clouds; wear protective clothing if so exposed. Wear a respirator while handling the wettable powder and during the spraying and dusting operations. Always wear natural-rubber gloves if you handle parathion. Wash the hands, arms, and face thoroughly with soap and water after using parathion and before eating or smoking. Bathe and change the clothes when you have finished handling it.

If parathion spray materials accidentally strike the face or arms, or the clothing becomes wet with it, change the clothing immediately and wash the exposed parts thoroughly.

If headache, blurred vision, weakness, cramps, nausea, diarrhea, or discomfort in the chest develops while you are using parathion or are in or about parathion-sprayed trees, stop work immediately, bathe, and change the clothing, and if the illness persists, call your doctor. Atropine is of value as an antidote in relieving acute symptoms of poisoning from this insecticide. Never use morphine.

EPN

EPN is a phosphorus insecticide with somewhat longer residual effects than parathion. Use it to control the grape berry moth and the grape mealybug. The most common formulation is a 25-percent wettable powder. Use it at 1 to 1½ pounds per 100 gallons of water. It is compatible with the commonly used insecticides and fungicides. Do not use it later than 21 days before grape harvest.

Caution: EPN is poisonous to human beings and animals. It should not be used in small home plantings or by those not experienced in handling insecticides. Observe the same precautions recommended for handling parathion.

Malathion

Malathion is a phosphorus insecticide with relatively low toxicity to mammals. It is comparatively safe to handle and is especially suitable for use in small home plantings and by inexperienced operators. In general, use it on grapes at 2

pounds of 25-percent wettable powder per 100 gallons of water for controlling grapevine aphids, grape leafhoppers, grape mealybugs, spider mites, grapevine tomato gall insects, and Japanese beetles. For Japanese beetle and mite control, a 4-percent dust is sometimes used at 35 to 40 pounds per acre or a spray containing 57-percent emulsifiable concentrate at 1 to 1½ pints per 100 gallons of water. Do not use malathion within 3 days of harvest. Follow the usual precautions for handling insecticides.

Spreaders and Stickers

Certain materials may be added to grape sprays so that the sprays will spread over the grape surface more evenly and adhere longer after they have dried. Although spreaders and stickers are not always necessary, they may increase the coverage and the periods of effectiveness of the early sprays when grape foliage is limited, especially when heavier concentrations of bordeaux mixture are used or lead arsenate. To avoid excessive spray residues at harvest, do not use stickers after the grapes reach buckshot size.

Various spreaders and stickers may be obtained commercially. Follow the manufacturer's directions—usually from 1 pint to 1 quart for each 100 gallons of spray. The emulsified, or miscible, oil spreaders and stickers are generally preferred. Add these materials to the spray mixtures last. They mix readily by ordinary tank agitation.

GENERAL SPRAY SCHEDULE FOR GRAPES

Because of the long growing season and the frequency of rains in Florida and other South Atlantic and Gulf States, the general spray schedule (p. 30) found so effective in controlling diseases in the region north of the Ohio River and east to the Atlantic coast has been inadequate. Therefore, if you reside south of Virginia, Tennessee, and Missouri, it would be advisable before planning your grape-spraying schedule to consult with your county agricultural agent or to write to your State college of agriculture for advice about the timing and the number of applications needed.

Although four or five applications of fungicides as recommended may give very satisfactory control of black rot, downy mildew, and anthracnose in northern areas, the number of applications may need to be doubled in the South to obtain as good results.

It cannot be too strongly emphasized that in the spray schedule the early sprays are necessary. Infection of leaves and canes must be prevented if clean fruit is to be produced. Little can be accomplished if spraying is postponed until the fruit begins to rot or insect damage appears.

GENERAL SPRAY SCHEDULE FOR CONTROL OF MAJOR DISEASES AND INSECTS OF GRAPES[1]

Spray	Time of application	Materials (pounds per 100 gallons of water)	Disease or insect	Remarks
1	When new shoots are 7 to 10 inches long.	Ferbam (2), bordeaux mixture (6:6:100), or zineb (1½).	Black rot Dead arm	Where black rot is serious, apply extra spray of bordeaux mixture (8:8:100) or ferbam (2 pounds) when young shoots are 1 to 2 inches long. Add DDT to this spray if overwintering grape leafhoppers or grape flea beetles are severe.
2	3 to 5 days before bloom	DDT, 50-percent WP[2] (1½ to 2); plus ferbam (2); bordeaux mixture (4:4:100); or zineb (1½).	Black rot Grape berry moth Japanese beetle Rose chafer	If early downy mildew is a problem, use bordeaux mixture (4:4:100) rather than ferbam. If grapes bloom while applying this spray, keep spraying pressure at 350 pounds per square inch or below. Add lead arsenate to this spray if red-banded leaf rollers are present.
3	Immediately after bloom (petal fall).	Same as for spray 2, except DDT only 1½; or methoxychlor, 50-percent WP (2); parathion, 15-percent WP (1); EPN, 25-percent WP (1); or parathion in combination with DDT or methoxychlor at above rates.	Black rot Downy mildew Grape berry moth Grape leafhoppers Grape rootworm Japanese beetle Red-banded leaf roller.	If red-banded leaf rollers are present, add a recommended insecticide to this spray (p. 18). If grape leafhoppers are abundant, malathion may be used (p. 14). If downy mildew is a problem, use bordeaux mixture (4:4:100) rather than ferbam. Do not use parathion or EPN in small home plantings.
4	10 to 15 days after spray 3 (first cover).	Same as for spray 3, except plus ferbam (2) or zineb (1½).	Black rot Grape berry moth Grape leafhoppers Grape rootworm Japanese beetle	Apply 250 to 300 gallons per acre.
5	35 to 45 days after grape bloom (second cover).	Same as for spray 3	Downy mildew Grape berry moth	Spraying before eggs hatch is important. If downy mildew is likely to develop, add bordeaux mixture (2:2:100) or zineb (1½ pounds) to this spray.

6	10 to 15 days after spray 5 (third cover).	Same as for spray 3	Downy mildew Grape berry moth Grape mealybug	Apply at least 40 days before grape harvest if DDT is used. See page 22 for grape mealybug control. If downy mildew is likely to develop, add bordeaux mixture (2:2:100) or zineb (1½ pounds) to this spray.

[1] Modifications may be necessary to adapt this schedule to the needs of each locality. Additional sprays, alternate spray materials, and some of the less common diseases and insects are described in the text. See General Precautions (p. 1) and Caution under Spray Materials (pp. 27–28).

[2] Wettable powder.

CAUSAL ORGANISMS OF GRAPE DISEASES

Disease	*Causal organism*
Anthracnose or bird's-eye rot	*Elsinoë ampelina* Shear
Bitter rot	*Melanconium fuligineum* (Scribn. & Viala) Cav.
Black rot	*Guignardia bidwellii* (Ell.) Viala & Ravaz
Cercospora leaf spot or angular leaf spot	*Mycosphaerella angulata* W. A. Jenkins
Cotton root rot or Texas root rot	*Phymatotrichum omnivorum* (Shear) Dug.
Crown gall	*Agrobacterium tumefaciens* (E. F. Sm. & Towns.) Conn
Dead arm	*Phomopsis viticola* Sacc.
Downy mildew	*Plasmopara viticola* (Berk. & Curt.) Berl. & de T.
Powdery mildew	*Uncinula necator* (Schw.) Burr.
Ripe rot	*Glomerella cingulata* (Ston.) Spauld. & Schrenk

COMMON AND SCIENTIFIC NAMES OF INSECT PESTS OF GRAPES

Common name	*Scientific name*
Achemon sphinx	*Pholus achemon* (Drury)
Climbing cutworms	*Feltia* and *Agrotis* spp.
Eight-spotted forester	*Alypia octomaculata* (F.)
Grape apple gall maker	*Schizomyia vitispomum* O.S.
Grape berry moth	*Paralobesia viteana* (Clem.)
Grape cane gall maker	*Ampeloglypter sesostris* (Lec.)
Grape curculio	*Craponius inaequalis* (Say)
Grape flea beetle	*Altica chalybea* (Ill.)
Grape leaf folder	*Desmia funeralis* (Hbn.)
Grape leafhopper	*Erythroneura comes* (Say)
Grape mealybug	*Pseudococcus maritimus* (Ehrh.)
Grape phylloxera	*Phylloxera vitifoliae* (Fitch)
Grape rootworm	*Fidia viticida* Walsh
Grapevine aphid	*Aphis illinoisensis* Shimer
Japanese beetle	*Popillia japonica* New.
Midges or gnats	*Cecidomyia viticola* O.S. *Dasyneura vitis* Felt *Lasioptera vitis* O.S.
Pomace fly	*Drosophila melanogaster* Meig.
Red-banded leaf roller	*Argyrotaenia velutinana* (Wlk.)
Rose chafer	*Macrodactylus subspinosus* (F.)

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U.S. GOVERNMENT PRINTING OFFICE: 1961 O—586437